MODELLING AND OPTIMUM REDESIGN OF RELUCTANCE MAGNETIC LEAD SCREW

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Keywords: Reluctance magnetic lead screw, Mechanical lead screw

ABSTRACT

This paper examines modelling and redesign of an existing reluctance magnetic lead screw (RMLS) linear actuator with the aim of investigating its general applicability and feasibility in industrial applications. The investigation arises from a practical example where a specific mechanical lead screw (MeLS) linear actuator provided by Linak is replaced by the redesigned RMLS linear actuator.

Linear actuators are widely used in various industries where some of the commonly used types are mechanical, hydraulic, and pneumatic actuators. While magnetic lead screws potentially can replace several types, this paper focuses on whether mechanical actuators can be replaced by magnetic actuators. Mechanical and magnetic lead screw linear actuators have most in common, compared to the hydraulic and pneumatic systems which excel in high forces and fast speeds with lower forces respectively. Mechanical actuators do not require systems with pumps or compressors and hoses and are therefore simpler to implement in various applications. Magnetic lead screws are similar in these aspects, but have several benefits such as higher efficiency, increased lifetime, and reduced noise, which is why it is of interest to replace mechanical actuators with magnetic.

The analysis of the MeLS actuator and its performance specifications form the basis of the modelling and redesign of the RMLS actuator. The aim is to redesign the RMLS such that it can replace the Linak actuator, meaning that it complies with its performance specifications. Experiments on the existing RMLS are used to determine its unknown key electrical, mechanical, and magnetic parameters and to verify the mathematical model of the RMLS. This is then used as a scaling tool in the redesign phase, which will include optimum design techniques.

Due to the difference in functionality between the two actuators, only parts of the performance specifications can be facilitated by the existing RMLS concept. The MeLS has a self-lock mechanism, which prohibits any unwanted motion to occur within the tolerated forces in static situations. This self-lock mechanism is not present in the original RMLS design, wherefore the motor is required to deliver a sufficient continuous force to counteract the applied load. Different solutions for restraining this problem of the RMLS are investigated and implemented in the redesign phase.

A comparison between the redesigned RMLS and the MeLS is, along with cost estimation of the RMLS, used to establish the relevant application conditions for a feasible use for the RMLS linear actuator.

Acknowledgement

The authors of this work gratefully acknowledge Grundfos for sponsoring the 10th MechMan symposium.